DNA-Linker Induced Surface Assembly of Ultra Dense Parallel Single Walled Carbon Nanotube Arrays

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Supplementary Materials

SWNT type	Linker spacer size (# bp)	Linker toehold size (# nt)	# of SWNTs counted	Percent of SWNTs assembled	σ	Average number of SWNTs per assembled array	σ	Average Maximum Width of assembled arrays
HiPCO P2	20	0	183	23.5%	3.1%	3.1	7.8	2.2
HiPCO P2	20	5	203	33.0%	3.3%	2.4	1.4	2.1
HiPCO P2	20	7	301	33.6%	2.7%	2.3	0.4	2.1
HiPCO P2	20	9	207	44.4%	3.5%	2.2	0.3	2.1
HiPCO P2	20	11	395	66.6%	2.4%	3.0	1.4	2.6
CoMoCat	20	7	370	81.6%	2.0%	3.3	3.7	2.6
CoMoCat	60	7	340	51.5%	2.7%	2.4	0.7	2.2

Table S1 The observed assembly efficiency f or single walled carbon nanotubes assembled using DNA linkers with 20 bp duplex spacers. A nanotube is considered to be assembled if it is a member of an array consisting of two or more parallel SWNTs.

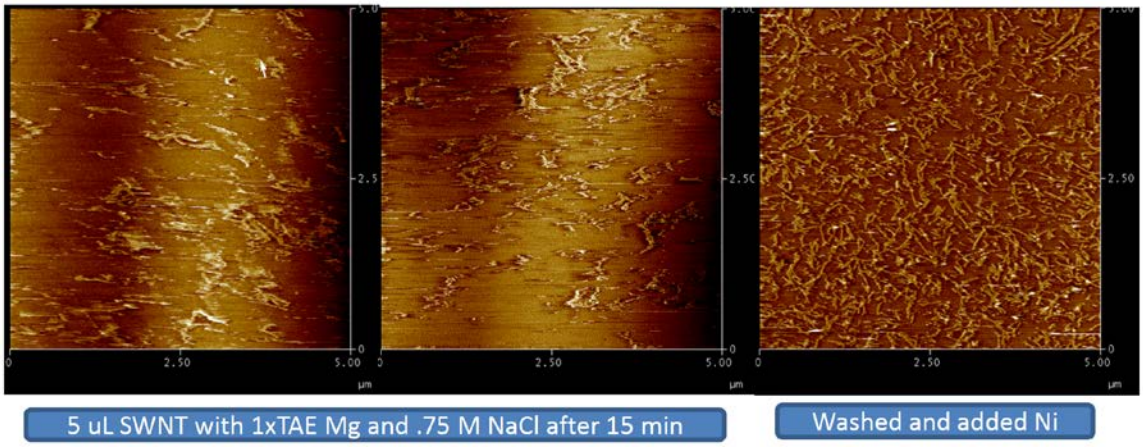

Figure S1 SWNTs were deposited on a mica surface and imaged under 1x TAE Mg with 0.75 M NaCl. Under tapping mode AFM, individual SWNTs cannot be imaged. The visible surface features appear to be clusters of aggregated nanotubes. After washing and buffer exchange to 1xTAE mg with ~1 mM Ni Acetate, numerous assembled carbon nanotube arrays can be seen.

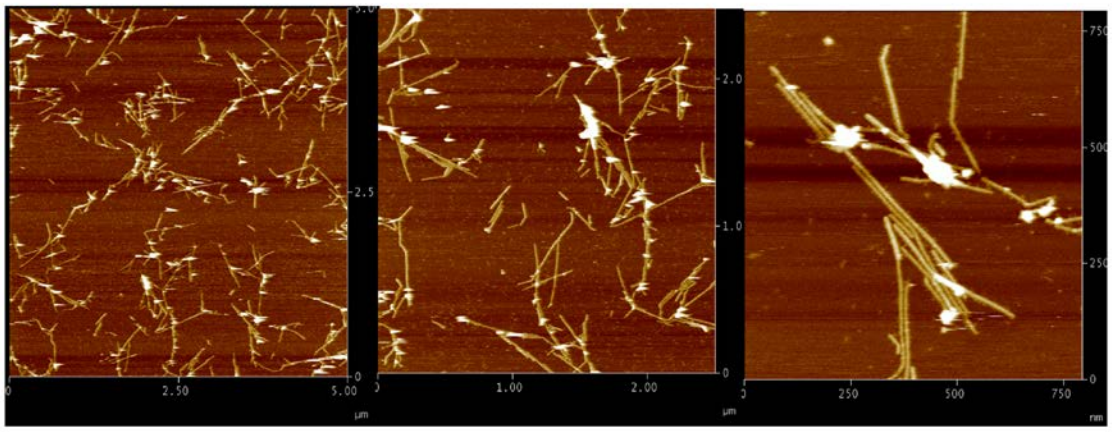

Figure S2 SWNT arrays assembled via surface assembly. For this experiment, the original SWNT solution was diluted 10x using 1xTAE Mg. 5 uL of the diluted solution was placed on a ~1 cm^2 piece of freshly cleave Muscovite mica, followed by 40 uL of 1xTAE Mg buffer. The solution was allowed to sit for 5 min, then the majority of the incubation solution was carefully removed using a 100 uL pipette. 40 uL of 0.75 M NaCl + 0.01 M Na2HPO4 solution was added. This was incubated at room temperature for ~2 hours. 50 uL of 1xTAE Mg was then added to the standing droplet on the mica surface, then 50 uL of solution was removed using a pipette. This was repeated 5 times. Finally, 7.5 uL of 10 mM Ni Acetate solution was added.

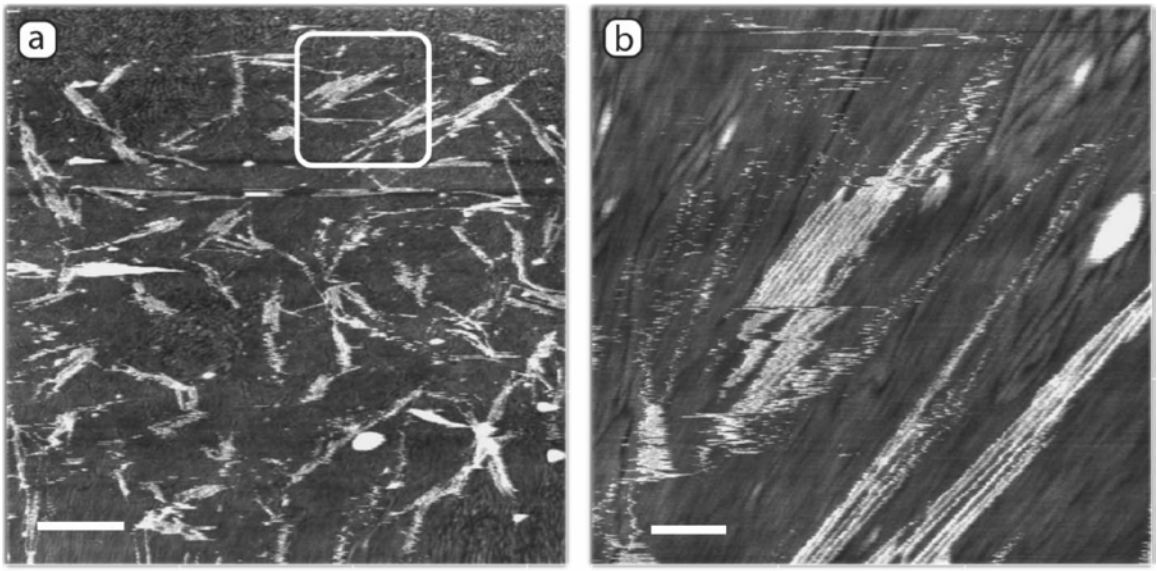

Figure S3 SWNT arrays formed in DPPC bilayer using 20 bp spacers with 9 base toehold. The boxed area in (a) is magnified in (b), showing an array with 11 parallel SWNTs. Scale bar are 500 nm in (a) and 200 nm in (b). (b) shows considerable distortion due to a problem with the AFM fluid cell.

Figure S4 A mica puck carrying assembled SWNT arrays is clamped to a GAPS II (Corning Biosciences) microarray slide. The microarray slide is cleaved, rinsed using MilliQ water and then blown dry using nitrogen. It is then clamped with to the mica puck, which is glued onto a 15 mm metal specimen disk from (Ted Pella, Redding, CA). The clamp is screwed finger tight. The setup is then left for 2 hours at room temperature.

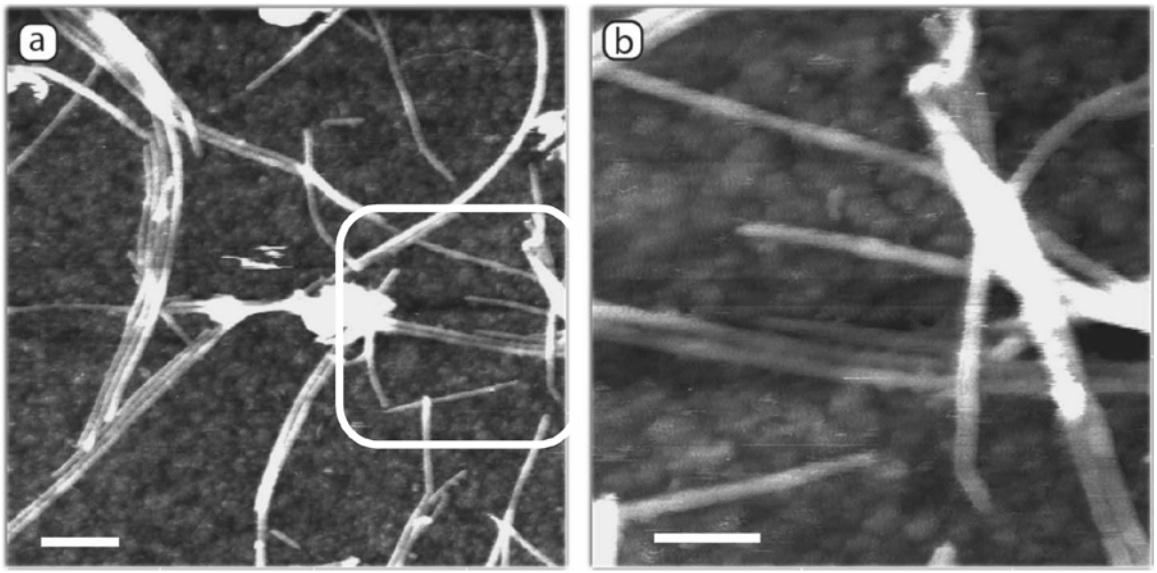

Figure S5 SWNT arrays formed on mica are stamped onto GAPS II microarray slides. (b) is a close up of the boxed area in (a). Scale bars are 100 nm in (a) and 50 nm in (b).

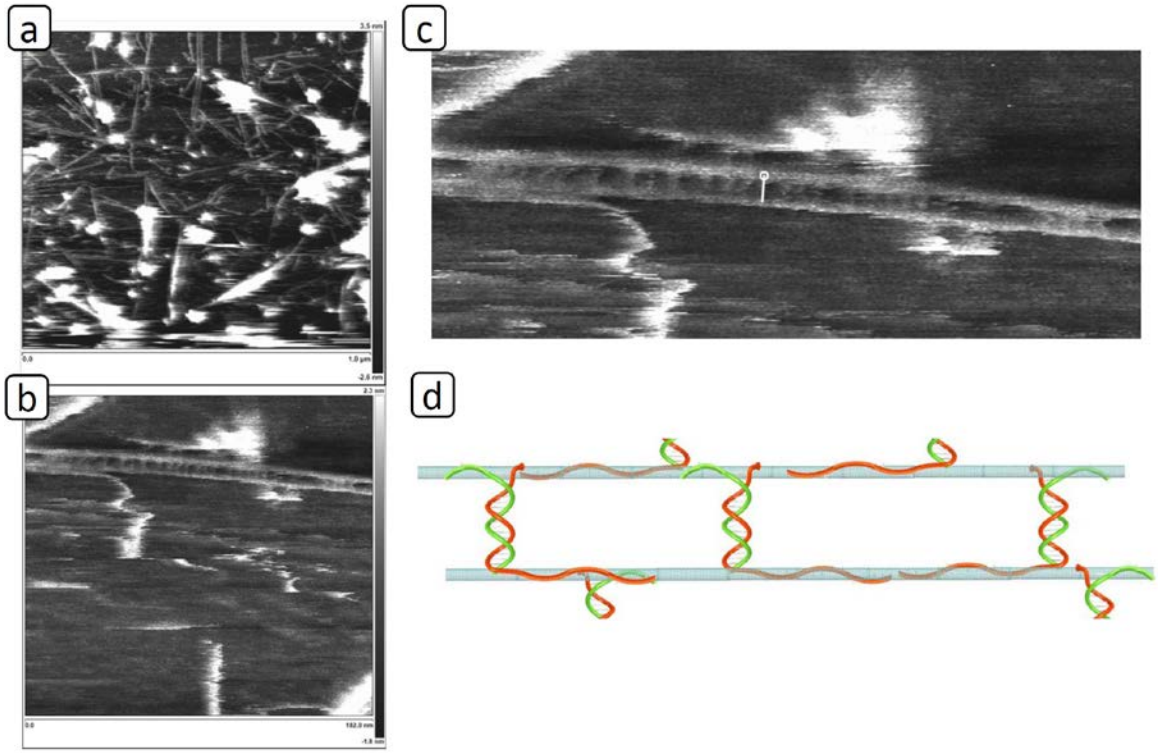

Figure S6 Tapping mode AFM images (topography) of SWNT arrays. (a) A 1 um by 1 um scan of SWNT dimers and trimers formed upon deposition of SWNTs under 1xTAE Mg buffer. (b) A 182 nm by 182 nm closeup of SWNT dimer. (c) Zoomed in view of the dimer in (b). The measurement mark shows a center to center distance of 7.3 nm between the two nanotubes. (d) Proposed structure of the SWNT "ladder".

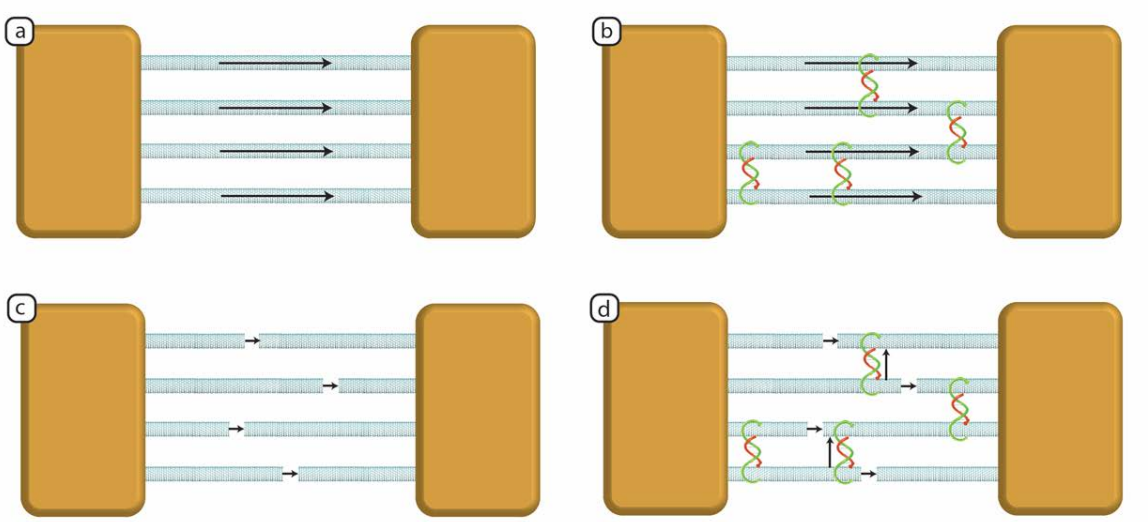

Figure S7 (a) Electrical currents flow through an array of parallel SWNTs contacted by 2 electrodes. (b) In this configuration, when macromolecules are suspended between adjacent SWNTs, it's still not possible to measure tunneling current through the macromolecules. (c) an array of SWNTs are broken at random positions by passing a high current through them, creating a number of gaps that destroy the normal conduction pathways. (d) The new configuration always creates overlaps where it's possible for current to tunnel from left electrode to the right through suspended macromolecules. It's now possible to measure these currents if the currents through the molecular analytes are similar or larger in magnitude compared to the tunneling currents through the gaps in the nanotubes.

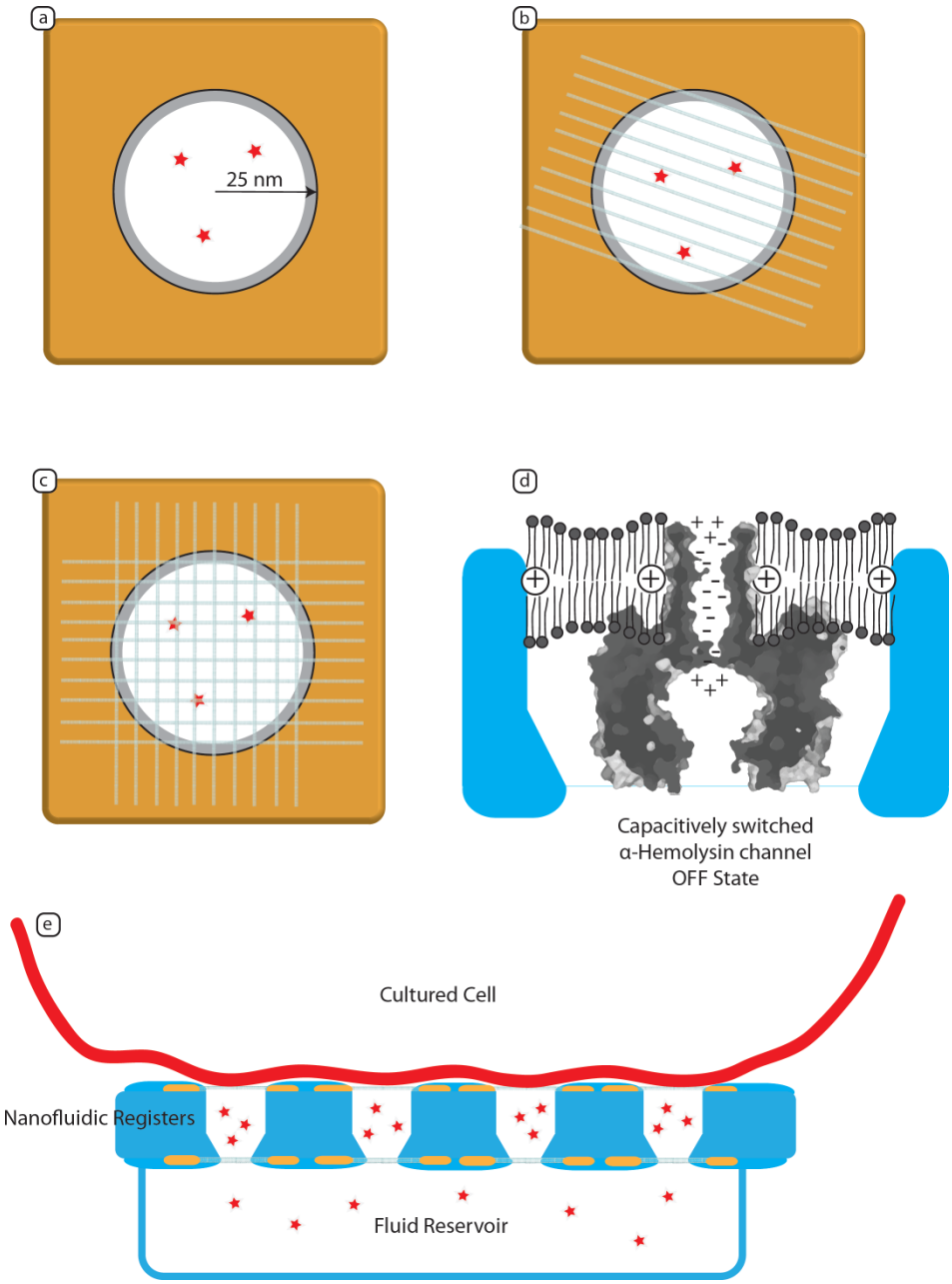

Figure S8 (a) A 50 nm nanopore is unable to modulate the transit of proteins and other molecules (stars) through the pore since Debye length in physiological buffer is ~1 nm (shown by the gray area) (b) With a grating of randomly oriented parallel SWNTs, biological molecules must now pass between the spaces between adjacent SWNTs, which can be adjusted according to the size of the gated molecule. An electrical potential applied to the SWNTs using the electrode can now effectively modulate the transit of the biomolecules. (c) It is also possible to create a mesh or more complicated multilayer

structures by printing multiple layers of SWNT arrays. (d) SWNT embedded within or situated on top of a lipid bilayer can electronically modulate transport through biological nanochannels such as α-hemolysin. In this case SWNTs spaced ~3 nm apart may be able to capacitively modulate ion flow through the α-hemolysin. E An array of "nanofluidic registers". Each register accumulates a precise amount of chemical signals for algorithmic release to a cultured cell. It may eventually be possible to use these types of array interfaces to achieve spatially and temporally resolved *exchange* of chemical information with living systems.